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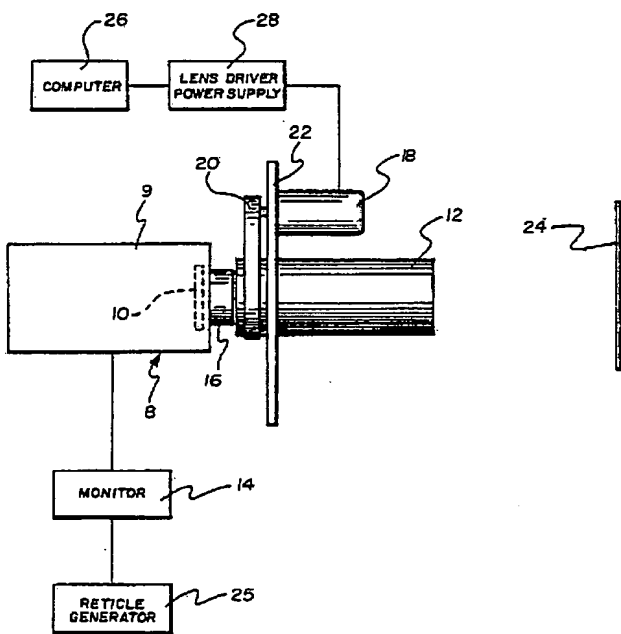
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(21) International Application Number: PCT/US90/00070 (22) International Filing Date: 4 January 1990 (04.01.90) (71) Applicant: EASTMAN KODAK COMPANY [US/US]; 343 State Street, Rochester, NY 14650 (US). (72) Inventor: MILLER, Martin, Leonard ; 29 Roxwood Circle, Rochester, NY 14612 (US). (74) Agent: FIELDS, Roger, A.; 343 State Street, Rochester, NY 14650 (US). (81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (Euro- pean patent), GB (European patent), IT (European pa- tent), JP, LU (European patent), NL (European patent), SE (European patent).		Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: METHOD AND APPARATUS FOR ALIGNING A ZOOM LENS WITH AN IMAGE SENSOR (57) Abstract <p>A zoom lens is driven by an oscillating drive in continuous motion between different states of magnification to cause an image on a video screen to expand and collapse about the point on the optical axis of the lens. The expanding and collapsing image is viewed on the video screen and the location of the optical axis of the lens assembly is determined by identifying the point on the screen that does not move. The lens assembly is then adjusted so that the stationary point coincides with a reticle at the optical center of the image sensor.</p> 		

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METHOD AND APPARATUS FOR ALIGNING
A ZOOM LENS WITH AN IMAGE SENSOR
CROSS REFERENCE TO RELATED APPLICATIONS

Reference is made to the following commonly
5 assigned copending applications:

1. U.S. Serial No. 122,995, now U.S.
Patent No. 4,809,064, entitled ENLARGING
PHOTOGRAPHIC PRINTER, filed November 19, 1987 in the
names of Shaun M. Amos, Richard J. Backus and Thomas
10 C. Jessop.
2. U.S. Serial No. 122,996, now U.S.
Patent No. 4,821,073, entitled METHOD AND APPARATUS
FOR MEASURING CHARACTERISTICS OF PHOTOGRAPHIC
NEGATIVES, filed November 19, 1987 in the names of
15 Patrick A. Cosgrove and Richard J. Backus.
3. U.S. Serial No. 292,687, entitled LENS
ADJUSTMENT APPARATUS, filed January 3, 1989 in the
name of Thomas C. Jessop.

TECHNICAL FIELD

20 This invention relates to alignment
apparatus and more specifically to apparatus and a
method for aligning a lens assembly with the optical
center of an image sensing device in a video camera.

BACKGROUND ART

25 In apparatus of the type disclosed in
commonly assigned copending applications Serial Nos.
122,955 and 122,996 for producing prints of selected
portions of negatives two independent optical
systems are utilized. One system images the
30 selected portion of the negative on the print paper
and the other images the selected portion of the
negative on an image sensor to display it on a
television screen for customer observation. The
customer has control of the negative and can, with
4 35 the aid of the television system, create and crop

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the picture he wants. To produce accurate prints corresponding to what the customer sees on the television screen, it is fundamental that the television and printing systems agree for pointing
5 and content.

In apparatus of the type described, accurate alignment of the camera to the zoom lens is required. The point on the sensor that corresponds to the center of the composing frame on the video
10 screen must be on the axis of the zoom lens. This is referred to as the optical center of the sensor. If the optical center of the sensor and the axis of the lens are not coincidental, the image formed at the optical center of the sensor will be a field
15 image for the lens. When the lens is zoomed, the field image will move due to the magnification change and cause a pointing error between the print and video systems.

One method of aligning the zoom lens is to
20 clamp the lens and move a single point target to the zoom lens axis by adjusting the target relative to the lens. When the target appears stationary through a zoom, the camera can be moved relative to the clamped lens and target system to bring the
25 sensor center into alignment with the non-moving target. This procedure is very inconvenient and time-consuming since the lens is supported by the camera.

DISCLOSURE OF THE INVENTION

30 It is an object of the present invention to provide a simple, reliable method and apparatus for aligning the optical axis of a zoom lens assembly with the optical center of an image sensor.

In accordance with the invention, a simple
35 procedure is utilized to identify the optical axis.

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The zoom lens is driven between different states of magnification to cause an image on a video screen to expand and collapse about its center. The expanding and collapsing image is viewed on the video screen and the location of the optical axis of the lens assembly is determined by identifying the point on the video screen that does not move. The lens assembly is then adjusted relative to the image sensor to superimpose the stationary portion on a reticle generated by the image sensor and known to be at the optical center of the sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages will become apparent from the following description taken in connection with accompanying drawings wherein:

FIG. 1 is a schematic view of a television system incorporating the present invention;

FIG. 2 is a schematic perspective view of the system shown in FIG. 1; and

FIGS. 3 and 4 are enlarged fragmentary views of the screen shown in FIG. 2 showing different conditions of operation of the system.

BEST MODE OF CARRYING OUT THE INVENTION

Referring to FIGS. 1 and 2 of the drawings, there is shown schematically video imaging system 8 comprising a video camera 9 having an imaging sensor 10, a zoom lens 12, and a monitor 14. The sensor 10 would preferably take the form of a charge coupled device (CCD) supported within the video camera housing. The housing and lens assembly can be physically coupled by a universal adjustment joint 16 which permits universal movement of the lens assembly relative to the sensor 10. The physical structure of the video camera, lens assembly and adjustment joint may take the form of that disclosed

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and claimed in commonly assigned copending application Serial No. 292,687, entitled LENS ADJUSTMENT APPARATUS filed January 3, 1989 in the name of Thomas C. Jessop and incorporated herein by reference.

The lens assembly 12 may comprise a typical zoom lens having a barrel containing a plurality of lens elements. A portion of the lens assembly is movable to effect zooming of the lens. In FIG. 1, a drive motor 18 is shown for rotating a portion of the zoom lens by means of a drive belt 20 to effect zooming, the motor being supported on a frame 22 extending from the lens assembly. Such video cameras and power zooming apparatus may take various forms known to those skilled in the art and further description is deemed unnecessary.

In accordance with the invention, the video imaging system 8 is positioned to capture the image of a target or screen 24 having a repeating orthogonal dot patterns. The target image and dot pattern will be displayed on monitor 14 for use in aligning the optical axis of the lens 12 with the optical center of the CCD 10 as will now be described.

To assist in the alignment process, selected areas of the monitor screen are activated by a reticle generator 25 to produce a diamond-shaped reticle image 23 on the monitor screen to identify the center of the composing frame and the optical center of the sensor.

The target image will appear on the monitor screen as a repeating dot pattern, as shown in FIGS. 2, 3 and 4. When the lens is zoomed to maximum magnification, the pattern will be enlarged as shown in FIG. 3. At minimum magnification, the dot

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pattern will be reduced in size as shown in FIG. 4. As the lens is zoomed from the state shown in FIG. 4 to that shown in FIG. 3, the dots not on the optical axis of the sensor will appear to move outward.

5 Similarly, when the lens is zoomed back to FIG. 4 magnification, the dots not on the optic axis will appear to move inward. The only point in the image plane that does not move during such zooming is the point or dot coinciding with the optical axis.

10 The stationary dot is conveniently located by oscillating the zoom lens between its high and low magnification states and observing the dot pattern. This is accomplished by connecting the zoom drive motor to an oscillating drive which is
15 depicted in block diagram in FIG. 3. In the disclosed embodiment, the oscillating drive comprises of a general purpose computer 26 programmed to drive a power supply 28 to produce a sawtooth motion of the zoom lens elements as
20 illustrated in FIG. 1. Such oscillating driving apparatus in general is well known to those skilled in the art and further description is deemed unnecessary. The drive motor will drive the zoom lens in one direction, reverse and then drive it in
25 the opposite direction to produce a rythmatic oscillation of the lens between its two extreme magnification states. If an oscillation frequency is selected in the range of 44 cycles per minute, the repeating dot pattern will appear to undergo
30 rhythmic zooming and the user need only observe the stationary dot which will be located at the intersection of two lines of dots, one line of which is moving vertically and the other of which is moving horizontally. After identification of the
35 stationary dot, the lens can be adjusted relative to

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the camera and CCD as necessary to produce a stationary dot at the CCD optical center defined by the reticle.

The invention thus provides a simple
5 reliable method and apparatus for aligning the optical axis of a zoom lens with the optical center of an image sensor. Specifically the invention eliminates the need to move the target because there is always another dot available on the screen as the
10 optical axis of the zoom lens is moved over the screen during the adjustment of the lens. The invention thus uses the combination of rhythmic zooming and a screen pattern to achieve simple, accurate alignment.

15 The screen 24 has been disclosed as a target having a dot pattern printed on its surface. However, it will be apparent to those skilled in the art that other repeating patterns can be employed. For example, the target could be a fabric having a
20 repeating weave pattern that would show a rhythmic movement during zooming.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those
25 skilled in the art that various changes may be made without departing from the scope of the invention defined by the appended claims.

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CLAIMS:

1. A method of aligning the optical axis of a zoom lens with an optical center of an image sensor comprising:
 - 5 capturing an image of a target having a pattern with the image sensor;
 - moving said lens between different states of magnification;
 - displaying the pattern image on a screen
 - 10 while moving said lens;
 - observing said pattern during said lens movement;
 - identifying a stationary portion of said pattern image during such observation; and
 - 15 adjusting said lens relative to the image sensor to cause the stationary portion to coincide with the optical center of the sensor.
2. A method as claimed in Claim 1 wherein the target has a dot pattern and a stationary dot is
- 20 identified as the location of the optical axis of the lens on the dot pattern.
3. A method as claimed in Claim 2 wherein the lens is rhythmatically moved between the states of magnification.
- 25 4. A method as claimed in Claim 3 further including the step of electronically creating a reticle on the screen to identify the optical center of the sensor.
5. Apparatus for aligning the optical axis
- 30 of a zoom lens with the optical center of an image sensor, said apparatus comprising:
 - a target having a repeating pattern adapted to be captured by the sensor;
 - means for zooming the lens between
 - 35 different states of magnification; and

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means for displaying the target image during zooming of the lens whereby a stationary portion of the pattern image can be identified to thereby identify the location of the optical axis on the pattern image.

6. Apparatus as claimed in Claim 5 wherein said zooming means includes means for oscillating said lens between said magnification states.

7. Apparatus as claimed in Claim 6 wherein said pattern is a repeating dot pattern.

8. Apparatus as claimed in Claim 6 wherein said target is a fabric having a repeating weave pattern.

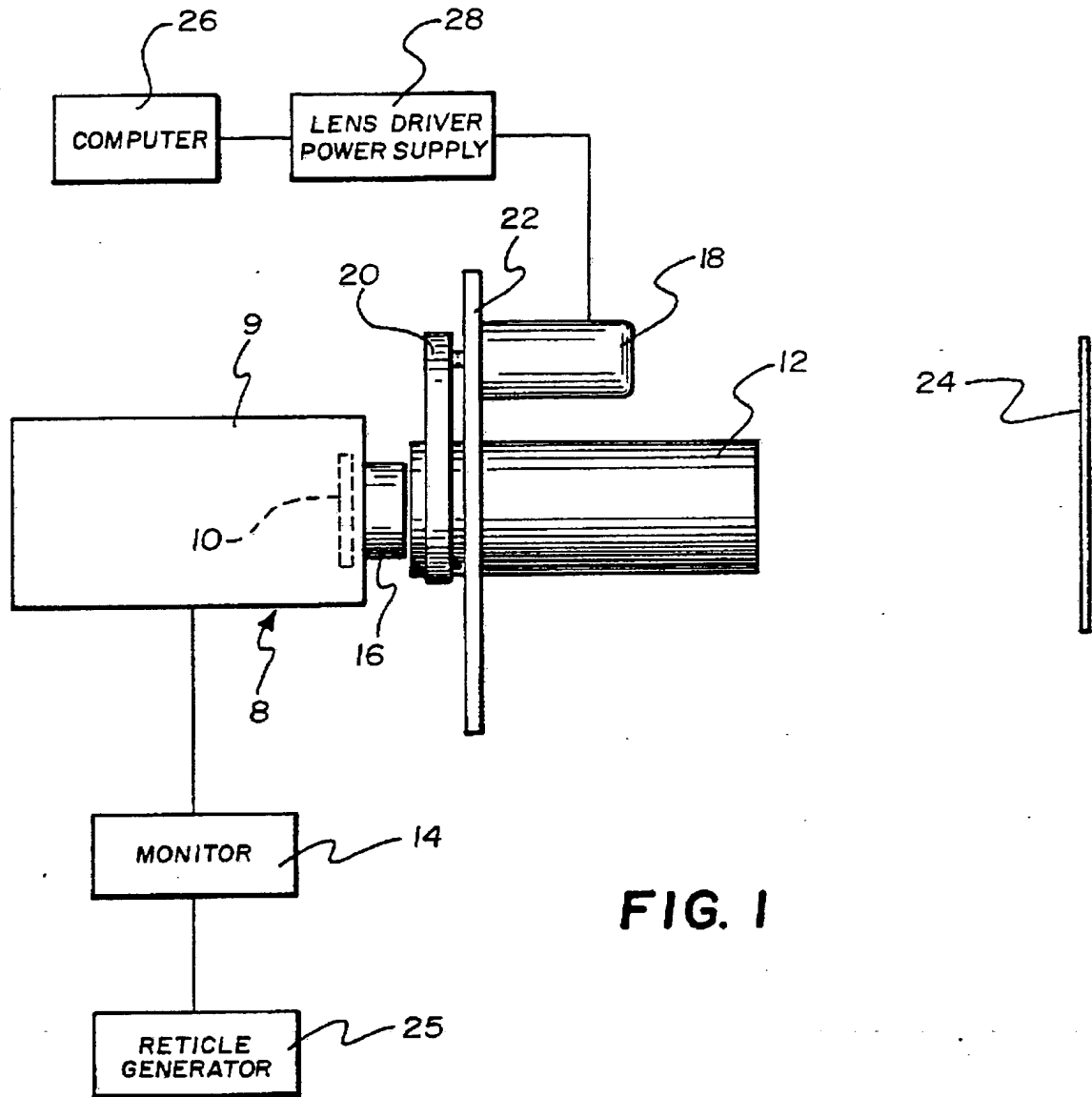
9. Apparatus as claimed in Claim 6 further including means for electronically establishing a reticle on said display means to identify the optical center of said sensor.

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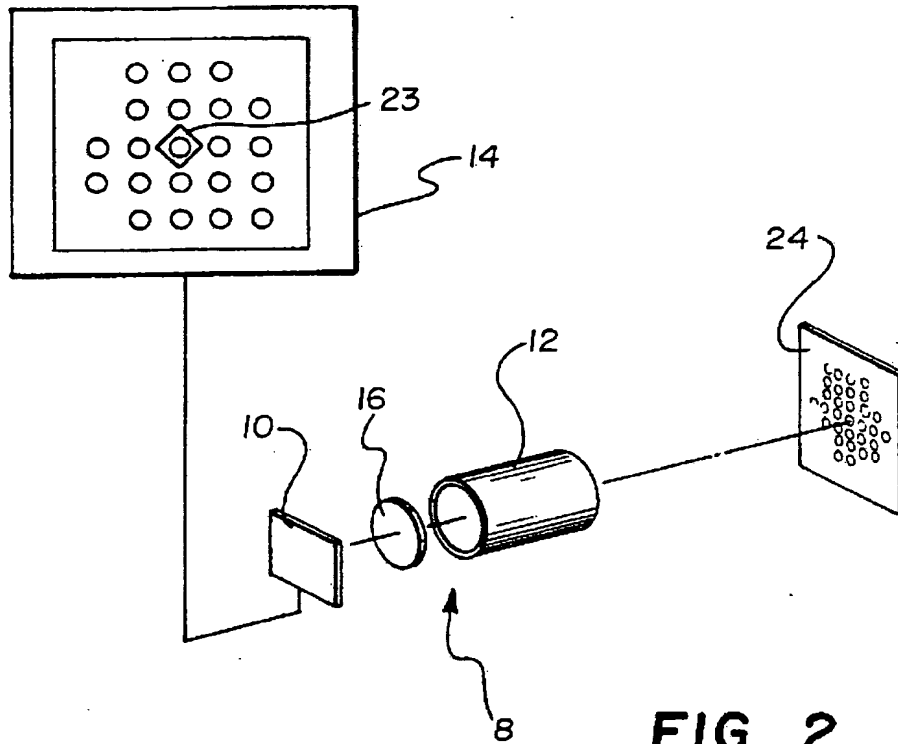


FIG. 2

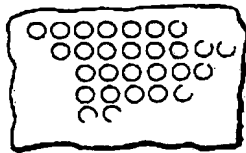


FIG. 4

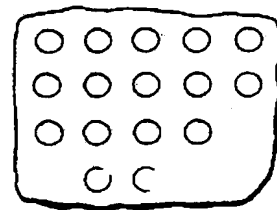


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No. **PCT/US 90/00070**

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: G 02 B 7/00, G 03 B 5/00																	
II. FIELDS SEARCHED <div style="text-align: right; font-size: small;">Minimum Documentation Searched *</div> <table style="width: 100%; border: none;"> <tr> <td style="width: 20%; border: none;">Classification System</td> <td style="border: none;">Classification Symbols</td> </tr> <tr> <td style="border: none; padding-top: 10px;">IPC5</td> <td style="border: none; padding-top: 10px;">G 01 B, G 01 D, G 02 B, G 03 B, G 12 B, H 04 N</td> </tr> </table> <div style="text-align: center; font-size: x-small; margin-top: 5px;">Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched *</div>			Classification System	Classification Symbols	IPC5	G 01 B, G 01 D, G 02 B, G 03 B, G 12 B, H 04 N											
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III. DOCUMENTS CONSIDERED TO BE RELEVANT* <table border="1" style="width: 100%; border-collapse: collapse; font-size: small;"> <thead> <tr> <th style="width: 10%;">Category *</th> <th style="width: 60%;">Citation of Document, *1 with indication, where appropriate, of the relevant passages **</th> <th style="width: 30%;">Relevant to Claim No. **</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">A</td> <td>Patent Abstracts of Japan, Vol 9, No 44, P337, abstract of JP 59-184309, publ 1983-04-04 MATSUSHITA DENKI SANGYO K.K. <div style="text-align: center;">---</div></td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">A</td> <td>Patent Abstracts of Japan, Vol 9, No 323, P414, abstract of JP 60-150016, publ 1985-08-07 RICOH K.K. <div style="text-align: center;">---</div></td> <td style="text-align: center;">1-9</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US, A, 4533950 (HARSHBARGER) 6 August 1985, see figure 2 <div style="text-align: center;">---</div></td> <td style="text-align: center;">7</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US, A, 4809064 (AMOS ET AL) 28 February 1989, see abstract; figures 1-2 <div style="text-align: center;">---</div><div style="text-align: center;">-----</div></td> <td style="text-align: center;">1-9</td> </tr> </tbody> </table>			Category *	Citation of Document, *1 with indication, where appropriate, of the relevant passages **	Relevant to Claim No. **	A	Patent Abstracts of Japan, Vol 9, No 44, P337, abstract of JP 59-184309, publ 1983-04-04 MATSUSHITA DENKI SANGYO K.K. <div style="text-align: center;">---</div>	1-9	A	Patent Abstracts of Japan, Vol 9, No 323, P414, abstract of JP 60-150016, publ 1985-08-07 RICOH K.K. <div style="text-align: center;">---</div>	1-9	A	US, A, 4533950 (HARSHBARGER) 6 August 1985, see figure 2 <div style="text-align: center;">---</div>	7	A	US, A, 4809064 (AMOS ET AL) 28 February 1989, see abstract; figures 1-2 <div style="text-align: center;">---</div> <div style="text-align: center;">-----</div>	1-9
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: 10</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 50%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to underlain the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Z" document member of the same patent family</p> </div> </div>																	
IV. CERTIFICATION <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Date of the Actual Completion of the International Search 5th April 1990</td> <td style="width: 50%; border: none;">Date of Mailing of this International Search Report 23. 04. 90</td> </tr> <tr> <td style="border: none;">International Searching Authority EUROPEAN PATENT OFFICE</td> <td style="border: none;">Signature of Authorized Officer <div style="display: flex; align-items: center;"> <div style="font-family: cursive; font-size: 1.2em; margin-right: 10px;">M. Peis</div> <div style="border: 1px solid black; padding: 2px 5px; font-size: 0.8em;">M. PEIS</div> </div> </td> </tr> </table>			Date of the Actual Completion of the International Search 5th April 1990	Date of Mailing of this International Search Report 23. 04. 90	International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer <div style="display: flex; align-items: center;"> <div style="font-family: cursive; font-size: 1.2em; margin-right: 10px;">M. Peis</div> <div style="border: 1px solid black; padding: 2px 5px; font-size: 0.8em;">M. PEIS</div> </div>											
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